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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

GREENAWAY et al

Serial No. **09/622,405**

Filed: **August 17, 2000**

For: **THREE DIMENSIONAL IMAGING SYSTEM**

Atty. Ref.: **124-786**

Group: **2872**

Examiner: **A. Amari**

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APPEAL BRIEF

On Appeal From Group Art Unit 2872

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I. REAL PARTY IN INTEREST

The real party in interest in the above-identified appeal is QinetiQ Limited by virtue of the Assignment from the inventors to The Secretary of State for Defence recorded August 17, 2000, at Reel 11046, Frame 596 and the subsequent Assignment from The Secretary of State for Defence to QinetiQ Limited recorded February 20, 2002, at Reel 12831, Frame 459.

II. RELATED APPEALS AND INTERFERENCES

There are believed to be no related appeals or interferences with respect to the present application and appeal.

III. STATUS OF CLAIMS

Claims 1-8, 10-18, 20 and 21 stand rejected in the third non-final rejection, with claims 9 and 19 allowed. The rejection of claims 5, 13 and 14 has not been appealed. With respect to the remaining claims, the Examiner contends that the remaining rejected claims 1-4, 6-8, 10-12, 15-18, 20 and 21 are obvious under 35 USC §103 in view of the cited prior art.

IV. STATUS OF AMENDMENTS

No further response has been submitted with respect to the third non-final Official Action in this application mailed December 2, 2002.

V. SUMMARY OF THE INVENTION

The present invention relates to a system for simultaneously imaging multiple objects or layers within a three-dimensional object field and has applicability in numerous fields including optical information storage, imaging short-timescale phenomena, microscopy, etc.

Undistorted amplitude gratings have been used to produce identical images of a single object plane scene with the image in several diffraction orders. While most of the image energy is concentrated in the zero order, the remaining energy is contained in the +1 and -1 orders. It is noted that distortions of such an amplitude grating may be used to produce phase changes in the optical system and thus shape the wavefront in the focal plane of the system.

It is also known in the prior art to image three-dimensional objects by using the through-focal series of images in which a series of images at different focal lengths are stored. An alternative method is forming simultaneously a matrix of images recorded through a matrix of lenses, each of the lenses provides for a different focus condition. A disadvantage of the "through-focal series" is that because the images are recorded sequentially, i.e., over a time duration, it's less than useful for recording the three-dimensional structures of a dynamically changing phenomena. The disadvantage of the "matrix of images" is that the

requirement of a matrix of lenses provides limited resolution equal to that delivered by an individual lens in the array.

Therefore a need has arisen to be able to simultaneously focus on a plurality of object planes and provide images in an image plane on a plurality of image detectors which are generally spatially separated to some degree. Appellants found that by utilizing a particular diffraction grating, i.e. one in which the grating is distorted in accordance with a quadratic function so that images could be formed from a plurality of different object planes and the resultant images detected in a plurality of images at least partially spatially separated in a direction perpendicular to the optical axis.

The present invention, therefore, is an apparatus for producing simultaneously a plurality of spatially separated images from a plurality of object planes comprising an optical system, a diffraction grating in concert with the optical system to produce images associated with each diffraction order and an image detector wherein the "**diffraction grating is distorted according to a quadratic function**" so as to cause "**images to be formed under various focus conditions from a plurality of different object planes**" and wherein the images are "**spatially separated in a direction having a non-zero component perpendicular to the optical axis.**"

VI. ISSUES

Whether claims 1, 4, 7, 8, 11-12, 15-18, 20 and 21 are obvious over Kubo in view of Shimano.

Whether claims 2, 3 and 6 are obvious over Kubo in view of Shimano in view of Lee.

Whether claim 10 is obvious under 35 USC §103 over Kubo in view of Shimano in view Torok.

VII. GROUPING OF CLAIMS

The rejected claims stand or fall together as indicated in independent claims 1 and 15.

VIII. ARGUMENT

1. Discussion of the References

Kubo (U.S. Patent 5,684,762) teaches an auto-focus system which includes a projector for focusing a single object plane onto two spatially separated images. As can be seen in Figure 3, a hologram plate 27 in conjunction with the condenser lens 28 serves to provide spatially separated images.

Moreover, there is no disclosure in Kubo that its diffraction grating is distorted according to a quadratic function so as to cause images from a plurality of different object planes to form images spatially separated along the optical axis in a direction perpendicular to the optical axis.

Shimano et al (U.S. Patent 5,930,220) teaches several embodiments of devices which will convert a single object image into a plurality of spatially separated images. Different object planes are utilized in different embodiments. Figures 6 and 7 illustrate an embodiment which has different lenses and a diffraction grating which will focus an object from one plane, i.e. disk 91 onto three spatially separated image planes 12 as shown in Figure 6 or focus a single object plane 92 onto a single one of the spatially separated image detectors 12.

In a further Shimano embodiment shown in Figure 9, a hologram 731 and a lens with two focal lengths serves to provide object images from two different distances to the system which generates the three spatially separated images. However, it is noted that polarization grating 5 in Shimano does not contribute to the generation of the three spatially separated images from the two object images.

Shimano fails to teach any diffraction grating which is distorted in accordance with a quadratic function so as to form a plurality of focus conditions focusing different object planes onto images spatially separated in a direction perpendicular to the optical axis.

Lee (U.S. Patent 5,721,629) teaches a dual-focus forming apparatus and takes into consideration wave-front aberration. There is no teaching that Lee utilizes any diffraction grating, especially a diffraction grating distorted according

to a quadratic function in order to produce different amounts of spherical aberration in the images.

Torok (U.S. Patent 3,861,784) is an apparatus for optical processing of an image. The Examiner alleges that Torok teaches a diffraction grating that is programmable. Programmable or not, there is no teaching set out in the Torok reference which discloses a diffraction grating which is distorted according to a quadratic function or which causes images to be formed from a plurality of different object planes and on a plurality of spatially separated (in a direction perpendicular to the optic axis).

2. Discussion of the Rejections

Claims 1, 4, 7, 8, 11, 12, 15-18, 20 and 21 stand rejected under 35 USC §103 as unpatentable over Kubo in view of Shimano. To the extent it is understood, it appears that the Examiner believes that Kubo teaches a diffraction grating which "is distorted in accordance to a quadratic function as described in column 4, lines 55-63." The Examiner also appears to believe that it would be obvious to somehow combine the Kubo and Shimano references and to ignore the specific teachings in the Kubo and Shimano references which are inconsistent with such combination.

Claims 2, 3 and 6 stand rejected under 35 USC §103 as unpatentable over the Kubo/Shimano combination in view of Lee. While the Examiner admits that

the Kubo/Shimano combination does not teach quadratic grating distortion to accommodate spherical aberration, he appears to believe that the Lee reference does teach such a grating and that it would be obvious to combine with the Kubo/Shimano combination.

Claim 10 stands rejected under 35 USC §103 as unpatentable over the Kubo/Shimano combination in view of Torok. To the extent it is understood, the rejection appears to indicate a belief that there is some reason for combining the Torok disclosure with the Kubo/Shimano combination or that Torok somewhere teaches a diffraction grating which is distorted in accordance with a quadratic function in the manner set out in appellants' claim 1.

3. The Errors in the Third Non-Final Rejection

There are at least three significant errors in the third non-final rejection and they are summarized as follows:

(a) No prior art reference teaches the diffraction grating claimed in independent claims 1 and 15;

(b) No prior art reference provides any reason or motivation for combining structures disclosed in the manner of appellants' claims; and

(c) The Shimano reference would actually lead one of ordinary skill in the art away from appellants' claimed combination of elements.

(a) No prior art reference teaches the diffraction grating claimed in independent claims 1 and 15

Appellants' independent claims 1 and 15 both require that the diffraction grating be "distorted according to a quadratic function so as to cause the images to be formed under various focus conditions from a plurality of different object planes and said images spatially separated in a direction having a non-zero component perpendicular to the optical axis."

As can be seen in appellants' Figure 10, a plurality of objects are located at different object planes 5, 6 and 7. The diffraction grating is distorted according to a quadratic function so that the resultant images are formed spatially separated in a direction perpendicular to the optical axis, i.e. in plane B at the +1, zero and -1 positions. While these positions can also be spaced in a direction parallel with the optical axis, the requirement of the diffraction grating is that they at least have a non-zero component perpendicular to the optical axis. This structure aids the present combination of elements to image an object in a three-dimensional fashion simultaneously as is desired by those in the art. Thus, the present invention solves the prior art problem of the reading of multi-layer optical data storage.

The Court of Appeals for the Federal Circuit has consistently held that "the PTO has the burden under §103 to establish a *prima facie* case of obviousness." *In re Fine*, 5 USPQ2d 1596, 1598 (Fed. Cir. 1988). The Court has held that the PTO "can satisfy this burden only by showing some objective teaching in the prior

art. . . ." *Id.* Thus, in order to establish a *prima facie* case of obviousness with respect to the independent claims and all claims dependent thereon, it is incumbent upon the Examiner to point out how or where applicant's claim elements are shown in the cited prior art references.

The Examiner has failed to do so with respect to the claimed diffraction grating, and in particular, with a diffraction grating distorted according to a quadratic function to cause images from a plurality of different object planes to be spatially separated with at least a component perpendicular to an optical axis. The Examiner suggests that diffraction grating 27 in Kubo is such a grating. This contention is respectfully traversed.

Appellant's claim requires that the grating be distorted consistent with a particular quadratic function, i.e. one which will cause images to be spatially separated along a component perpendicular to the optic axis when taken from a plurality of different object planes. Clearly, Kubo uses only a single object plane as shown in Figures 2, 3, 5 and 13. How or where the Examiner believes there to be a "plurality of different object planes" in Kubo such that the diffraction grating provides "images spatially separated in a direction having a non-zero component perpendicular to the optical axis" is simply not seen. Accordingly, Kubo fails to teach the structure of the claimed diffraction grating.

While the Examiner does not allege that Shimano is combined with Kubo in his discussion of claims 1 and 15, a review of the Shimano reference will also indicate that there is no such diffraction grating taught. The most pertinent figure in Shimano, Figure 9, shows two different object planes which have images which are spatially separated perpendicular to the optical axis. However, as is discussed in Shimano, a dual focal point lens 73 provides for the image from two separate object planes and then this image is processed by hologram 731 and polarizing type diffraction grating 5 to create the spatially separated images 12.

There is no teaching that a single diffraction grating distorted in accordance with a quadratic function could cause such spatial separation in the images, let alone teaching that one should be used in this application.

As a result of the above, it is clear that neither Kubo nor Shimano teach the specifically recited diffraction grating in appellants' independent claims 1 and 15. As a result, the Examiner and the Office has failed to establish a *prima facie* case of obviousness of independent claims 1 and 15 and all claims dependent thereon.

(b) No prior art reference provides any reason or motivation for combining structures disclosed in the manner of appellants' claims

The Patent Office has improperly combined the Kubo and Shimano references. The Court of Appeals for the Federal Circuit has consistently held that there be some motivation or reason for combining references and not merely the

fact that the references teach components which could be combined in the manner of applicant's claims. The Court of Appeals for the Federal Circuit held in the case of *In re Rouffet*, 47 USPQ2d 1453, 1457-8 (Fed. Cir. 1998) that

> "to prevent the use of hindsight based on the invention to defeat patentability of the invention, this court **requires** the examiner to show a motivation to combine the references that create the case of obviousness. In other words, the **Examiner must show reasons** that the skilled artisan, confronted with the same problems as the inventor and with no knowledge of the claimed invention, would select the elements from the cited prior art references for combination in the manner claimed." (emphasis added).

Kubo, in the Summary of the Invention, specifies that the primary object is "to provide a simple lightweight and compact opto-magnetic head apparatus having a simple optical system and a simple electric or electronic circuits including a signal . . . ." The simple optical system discussed is an auto-focus system as discussed throughout the specification ("a pair of servo-signal light receiving elements 32a and 32b are adapted to detect the focus error signal FE and the tracking error signal TE, as shown in Fig. 3" (column 6, lines 28-30) and "when the image is focused, the position and diameter of the beam spots incident upon the servo-signal light receiving elements 32a and 32b are identical, as shown in Fig. 9" (column 6, lines 47-50).

Quite clearly, Kubo is not directed to the problem of imaging a three-dimensional object or imaging something from a plurality of object planes.

Rather, Kubo is solely directed towards being able to focus a laser on a single object plane and to maintain that focus even if that object plane changes position. Thus, Kubo has nothing to do with the present invention being able to read multilevel media.

Shimano is a tracking method for disks which in several embodiments (Figures 6 and 7) can obtain data from different object planes. However, in Shimano in order to do so, the lens 71 is substituted for the lens 72 (Figure 6 shows lens 71 in the optical path and Figure 7 shows lens 72 in the optical path). Thus, Shimano teaches an apparatus which can read object material from two different object planes, but this cannot be done simultaneously, as only one lens is in the optical path at a time.

In Figure 9 of Shimano, there is disclosed a structure which will read from two object planes simultaneously. In order to accomplish this operation, a "two-focal points lens 73" is provided and a hologram 731 is also provided. These two elements are in addition to the polarization diffraction grating 5 and, from the two different object planes, these three elements create the images which are spatially separated. However, Shimano does not teach a diffraction grating which will cause images to be formed from a plurality of object planes wherein the images are spatially separated in a direction perpendicular to the optical axis.

Instead of appellants' simplified diffraction grating, Shimano requires the named "two-focal points lens 73" and "hologram 731" in addition to "the polarizing type diffraction grating 5." While a similar object is being achieved in appellants' claims 1 and 15 and in the Shimano reference, the structure used in Shimano does not teach or render obvious the structure used in appellants' independent claims.

Again the burden is on the Examiner to provide some motivation or reason for combining the two references. Because Kubo is an auto-focus device attempting to focus a beam or image from a single object plane, there is no reason for one to combine it with Shimano which is designed to read two different types of media (a CD and a DVD). While Shimano does attempt to perform the detection as claimed in appellants' independent claims, it does so with a complex structure of the dual-focus lens, the hologram 731 and the polarizing diffraction grating, instead of the simple structure of appellants' independent claims 1 and 15. There is no disclosure in Shimano that the same result could be accomplished with a distorted grating in accordance with appellants' claims, and there is certainly no reason to try combining the two references to achieve appellants' claimed invention.

In accordance with the above, the Examiner has simply failed to point out any reason or motivation in either the Kubo or Shimano references or with one of

ordinary skill in the art for taking bits and pieces of the two references and combining them in the manner of appellant's independent claims.

(c) The Kubo and Shimano references would actually lead one of ordinary skill in the art away from appellants' claimed combination of elements

As also noted by the Court of Appeals for the Federal Circuit, it is "error to find obviousness where references 'diverge from and teach away from the invention at hand'." *In re Fine*, at 1599. Both references appear to teach away from appellants' claimed combination of elements.

Kubo teaches a single object plane and an auto-focus system with a diffraction grating and thereby would lead one of ordinary skill in the art away from attempting to form images from a plurality of different object planes as in appellants' independent claims. The Shimano reference would lead one of ordinary skill in the art away from appellants' claimed combination of elements, because it teaches that, in order to image different object planes and to form images which are spatially separated, one requires not only a diffraction grating, but a dual focus lens 73 and a hologram 731.

There is no reason why anyone of ordinary skill in the art would consider substituting appellants' claimed diffraction grating for the combination of elements recited or disclosed in the Shimano reference, and since Shimano teaches that

these three elements work, it would clearly lead one of ordinary skill in the art away from appellants' invention.

Because both the Kubo and Shimano references "teach away from" the claimed invention, there is no basis for an obviousness rejection in view of these two references.

Inasmuch as there is no proper basis for rejection of claims 1 and 15, there is no proper basis for rejection of the claims dependent thereon, and it is unnecessary for appellants to address the details of those additional references. Suffice it to say that the Examiner has not alleged that the missing elements of appellants' claims 1 and 15 are shown in, nor is there any reason for combining these references disclosed in the Torok or Lee references.

IX. CONCLUSION

Appellants' detailed analysis of the two primary references clearly establishes that neither reference teaches appellants' claimed diffraction grating. Moreover, even if one reference contained such a teaching, the Examiner has failed to provide any motivation or reason for combining bits and pieces of these two references in the manner claimed. Further, the Examiner appears to have ignored that the two references actually teach away from appellants' combination of elements. As a result, the Examiner has clearly failed to establish a *prima facie* case of obviousness by failing to point out where claimed structure is clearly

illustrated, by failing to point out a reason for combining the references and ignoring the fact that the references teach away from the claimed combination.

Thus, and in view of the above, the rejection of claims 1-4, 6-8, 10-12, 15-18, 20 and 21 over the cited prior art is clearly in error and reversal thereof by this Honorable Board is respectfully requested.

Respectfully submitted,

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By: _____

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SCS:kmm
Enclosures
Appendix A - Claims on Appeal

APPENDIX A

Claims on Appeal

1. An apparatus for producing simultaneously a plurality of spatially separated images from a plurality of object planes, said apparatus comprising:

an optical system arranged to produce an image associated with a first focus condition;

a diffraction grating arranged to produce, in concert with the optical system, images associated with each diffraction order; and

means for detecting the images, wherein the optical system, diffraction grating and detecting means are located on an optical axis and the diffraction grating is located in a suitable grating plane and the diffraction grating is distorted according to a quadratic function so as to cause the images to be formed under various focus conditions from a plurality of different object planes and said images spatially separated in a direction having a non-zero component perpendicular to the optical axis.

2. The apparatus of claim 1 where the function according to which the grating is distorted includes further terms for producing different amounts of spherical aberration in the images associated with each diffraction order.

3. The apparatus of claim 2 where the spherical aberration of images associated with each diffraction order is arranged to correct for spherical aberration associated with the different depths of substantially parallel planes in object or image space.

4. An apparatus according to claim 1, whereby the origin of the distortion function of the diffraction grating is displaced from the optical axis.

6. An apparatus according to claim 1 whereby the diffraction grating comprises a set of two or more diffraction gratings designed such that the various diffraction orders are spatially separated.

7. An apparatus according to claim 1 whereby the diffraction grating is any one of an amplitude-only diffraction grating, a phase only diffraction grating or a phase and amplitude diffraction grating.

8. An apparatus according to claim 1 whereby the diffraction grating is polarisation sensitive.

10. An apparatus according to claim 1 whereby the diffraction grating is a programmable grating.

11. An apparatus according to claim 1 whereby the diffraction grating is a reflective grating or a transmissive grating.

12. An apparatus according to claim 1 whereby the grating is any of a two-level (binary) structure, a multi-level (digitised) structure or a continuous-level (analogue) structure.

15. An apparatus for producing simultaneously a plurality of spatially separated images from an object field comprising:

an optical system arranged to produce an image associated with a first focus condition;

a diffraction grating arranged to produce, in concert with the optical system, images associated with each diffraction order and

means for detecting the images, wherein the optical system, diffraction grating and detecting means are located on an optical axis and the diffraction grating is located in a suitable grating plane and the diffraction grating is distorted according to a quadratic function so as to cause the images to be formed under various focus conditions and said images spatially separated in a direction having a non-zero component perpendicular to the optical axis, adapted for producing substantially in focus images in a common image plane, from a plurality of object planes.

16. The apparatus of claim 15 wherein the object planes are coincident with the image planes.

17. The apparatus of claim 15 where each object plane contains an array of elements, capable of existing in at least two states and in which the detector means is capable of distinguishing between said states.

18. The apparatus of claim 17 adapted for reading data from a three dimensional optical storage medium wherein object planes are located within the medium and the detecting means is capable of producing a signal dependent on the state of the elements.

20. A wavefront analyser including an apparatus for producing simultaneously a plurality of spatially separated images from a plurality of object fields according to claim 1.

21. A passage ranging device including an apparatus for producing simultaneously a plurality of spatially separated images from a plurality of object fields according to claim 1.